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THE WATER SNAKES OF SOUTHERN MICHIGAN.

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THE water snakes of the genus Natrix offer some puzzling problems, not only to the systematist, but also to the student of geographical distribution. There can be no doubt that much of the difficulty is due to our lack of knowledge; for, unfortunately, the study of living snakes is not especially popular, and preserved specimens are so apt to lose their normal colors that the proper comparison of snakes from different localities becomes a matter of very great difficulty. The occurrence of a red-bellied water snake in southern Michigan has been known for many years, but its relation to the common water snake, *Natrix fasciata sipedon* (L.), has never been satisfactorily determined. It was with the hope of throwing some light upon the solution of this problem that the work was undertaken, the results of which are embodied in this paper. During the past two years one hundred water snakes captured in the vicinity of Olivet, Mich., have been examined, and careful observations have been recorded, from the living or freshly killed specimens, in regard to sex, size, proportions, and color, and the number of scale rows, gastrosteges (plates on belly, in front of vent), and

urosteges (plates on ventral side of tail, behind vent). Special attention was also given to habits, food, and localities where captured. All the specimens were taken in the months of April, May, and June. While the number of snakes thus handled is not so large as had been desired, the results obtained are of sufficient interest and importance to warrant publication, in the hope that observers elsewhere will make similar records and thus enable us to ascertain the truth in regard to our common water snakes and their distribution.

NATURAL HISTORY.

Much of the country around Olivet is low and swampy; small lakes connected by more or less sluggish streams are of frequent occurrence, and even in dry summers there is no lack of water. No wonder, therefore, that water snakes are common, especially if one has learned when and where to look for them. Three easily distinguished forms occur, which are designated by Cope[1] as *Natrix leberis* (L.), *N. fasciata sipedon* (L.), and *N. f. erythrogaster* (Shaw). The first of these is the smallest and the least common. The largest specimen met with was 747 mm. in length, but all of the others were less than 700 mm. There are only nineteen rows of dorsal scales, and the olive color, with three narrow, longitudinal black stripes on the back, and a buff lateral stripe very prominent anteriorly, is also very characteristic. Cope says that this species shows "very little variation in any respect," but the few specimens I have examined show a great deal of diversity in the distinctness of the stripes and the amount of slate on the belly. Judging from what I have seen of its habits, this snake is very fond of the water, as I have never found it out of that element, except when sunning itself on branches immediately above some stream or the edge of a pond. The two snakes which are regarded by Cope as subspecies of *N. fasciata* are much more abundant than *N. leberis*, and all of my detailed observations have been made upon them. Both are very aquatic

[1] Cope, E. D. *The Crocodilians, Lizards, and Snakes of North America.* Washington, Government Printing Office, 1900.

in their habits, but *erythrogaster* (known about Olivet as the "red-bellied black snake") is more often seen away from the water, and several specimens were taken a rod or more from the nearest stream, while *sipedon* is rarely seen more than a few feet from water. Both are very active, and when once alarmed are very shy, but *erythrogaster* is decidedly the more wary and somewhat more rapid in its movements. Both swim with speed and grace and can remain under water for some time. Their food consists chiefly of frogs, toads, and fish; no other animal remains were found in the stomachs. They capture fish of considerable size,—a large *sipedon* having swallowed, just previous to capture, a sucker (Catostomus) a foot in length. Fish are usually, perhaps always, swallowed head first, but frogs and toads are taken either way. Both *sipedon* and *erythrogaster* will strike repeatedly and savagely when cornered, but the bite is absolutely harmless, and though the teeth may be strong enough to break the skin and draw blood, the wound is practically painless and heals quickly, unless the teeth, which are very small and easily torn from the jaw, remain in the wound. Like all of our snakes, these water snakes have a very strong odor, especially during the breeding season. This odor is due to a thick fluid secreted in glands situated at the base of the tail and opening to the exterior at the sides of the vent. These glands are 20 mm. long, more or less, and are present in both sexes, but in the male they lie above the hemipenes and are therefore less easily discovered. The secretion of *sipedon* is yellowish or brownish in color and has an odor difficult to describe but very characteristic; to me it smells slightly "burnt" and is very disagreeable. The secretion of *erythrogaster* is white or pale yellow and has a slightly acid, musky odor quite different from that of *sipedon*, and, to me, not so disagreeable. Such statements are obviously insufficient to enable another observer to make much use of them, but it is practically impossible to so describe an odor of this kind as to make it recognizable. The difference between the two kinds of snake is, however, very marked to any one smelling first one and then the other.

Both of these water snakes are accustomed to come out of the water, especially on sunny days, and lie, more or less coiled,

upon the bank, on logs in or beside the water, upon the branches of bushes overhanging the water, or upon piles of brush through the open spaces of which they can drop quietly down into the water below. Such piles of brush are their favorite spots, and one often sees three or more snakes coiled up together on the same pile. When so resting they seem rather stupid and may be closely approached and killed with a stick; but I think this is due, not to stupidity, but to reliance upon their protective coloration, for when once convinced that they are observed they will glide into the water without delay. That the coloration of both forms is protective is perfectly obvious to any one who has observed them in their natural haunts. The resemblance to an old stick, when they are lying motionless in the water or on brush piles, is so great that it is often very difficult for an unpracticed eye to detect them. They apparently frequent the same spot day after day, for weeks at least, if not too seriously disturbed. They seem to become more wary with experience; a fine large specimen of *erythrogaster* tempted me no less than six times to a certain spot, but each time he was more wary, and I failed in all my attempts to capture him. In no case were *sipedon* and *erythrogaster* found on the same pile of brush, and specimens of the two forms were never seen together or even near each other, although males of *erythrogaster* were on several occasions found mating with females of the same form, and male *sipedons* with females of their own race.

The local distribution of *erythrogaster* is peculiar. While *sipedon* is found about every pond or stream near Olivet, *erythrogaster* seems to be confined to a tract of low land, lying to the east of the village and bordering a creek which connects Pine Lake with the Olivet mill pond. This area is about a mile long and less than a quarter of a mile wide, but I know of no specimens of *erythrogaster* having been taken elsewhere. An advertisement was inserted in the local paper, offering a good price for red-bellied black snakes, and thirteen were brought to me in response, but every one was taken within the area designated. The common *sipedon* also occurs in that area but is not very frequent. It is difficult to account for this peculiar localization of *erythrogaster*, as I cannot see that

the environment is essentially different from that offered by other creeks near by.

Differences due to Age and Sex.

Soon after the collection of statistics was begun, it became apparent that the two sexes could be easily distinguished by external characters, and later on it was seen that the proportions of the body were different in very young snakes from what they were in the adults. (Perhaps it ought to be stated that age is assumed to be correlated with size, and snakes less than 500 mm. in length are regarded as young.) Before we pass on, therefore, to a comparison of *sipedon* and *erythrogaster*, it is important to make clear the differences which are dependent on age and sex.

1. *Relative Length of Head and of Tail, and Diameter of Eye, in Old and Young.* — If comparison is made between the five largest females and the five largest males, on the one hand, and the five smallest females and the five smallest males, on the other, of *sipedon*, it becomes clear that in young snakes the head and tail are longer in proportion to the body, and the eye is larger in proportion to the head, than in adults. While this is what might be expected, it is interesting to see how considerable the difference is. The form *sipedon* is used for comparison because the far greater number of specimens examined makes the contrast more marked. This table shows that if a snake 937 mm. long kept the same proportions when adult that were shown when it was 505 mm. long, it would have a

Table I.

	Length of Tail in Percentage of the Total Length.	Length of Head, to Posterior Edge of Occipital Plates, in Percentage of Length of Body.	Diameter of Eye in Percentage of Length of Head.
10 large *sipedons*, averaging 937 mm.	22.3%	3.2%	18.3%
10 small *sipedons*, averaging 505 mm.	23.1%	3.8%	20.2%

tail 6 mm. longer, a head 4.6 mm. longer, and an eye nearly half a millimeter larger than it does have. While the difference in length of tail is thus rather small, the difference in head and eye is very considerable.

2. *Relative Length of Tail in Males and Females.*— If comparison be made between the males and females of either *sipedon* or *erythrogaster*, the difference in the proportion of tail and body in the two sexes is very marked.

TABLE II.

Species.	Sex.	Number of Specimens.	Average Length.	Maximum Length of Tail in Percentage of Total Length.	Minimum Length of Tail in Percentage of Total Length.	Average Length of Tail in Percentage of Total Length.
Erythrogaster	♂	16	977	25.3%	22.4%	23.7%
Erythrogaster	♀	8	1060	21.9%	20%	20.9%
Sipedon	♂	33	657	26.7%	23.3%	24.8%
Sipedon	♀	25	808	22.5%	16.3%	21.1%

The above table includes all of the water snakes examined in which the tail was uninjured. It will be seen that while the males average very much smaller in size, the tail is very much longer than in the females. Indeed, in both *sipedon* and *erythrogaster* the maximum tail measurement for a female falls short of the minimum for a male, while the average for a female is approximately 3 per cent less than for the male. It thus appears that a snake 800 mm. long will be found to be a male if the tail is over 180 mm., and a female if the tail is less than 180 mm. Ordinarily a male snake 800 mm. long will have a tail not less than 24 mm. longer than a female of the same size.

3. *Number of Urosteges in Males and Females.*— If a comparison be made between the number of urosteges in males and females, it becomes evident that here again there is a marked sexual difference.

These numbers refer to the urosteges of one side only, the actual number being double the above, since these plates are arranged in alternating pairs. Occasionally there is one more

TABLE III.

Species.	Sex.	Number of Specimens.	Maximum Number of Urosteges.	Minimum Number of Urosteges.	Average Number of Urosteges.
Erythrogaster	♂	16	82	68	77
Erythrogaster	♀	8	71	62	67
Sipedon	♂	33	79	68	74
Sipedon	♀	25	69	58	63

urostege on one side than on the other, but in such cases the larger number was recorded. A water snake with more than 70 urosteges is (in southern Michigan) almost certainly a male, while one with less than that number is almost as surely a female, only three males, out of 49 examined, having less than 70. It is interesting to see that the number is not dependent at all upon the size of the snake. The five largest females of *sipedon* average 62.6 urosteges apiece, and the five smallest average precisely the same, while the five largest males average 72.4, and the five smallest, 72.6.

4. *Correlation between Length of Tail and Number of Urosteges.* — It is a noteworthy fact, though quite in accord with what might be expected, that there is a certain amount of correlation between the length of the tail and the number of urosteges. Thus, we find that the males of *sipedon* which have tails 25 per cent of the total length, or longer, average 75 urosteges apiece, while those in which the tail is less than 24 per cent average only 71. The females which have tails 22 per cent of the length or over average 65 urosteges apiece, while those which have tails less than 21 per cent average considerably less than 62. Thus, for each one per cent in the length of the tail of *sipedon* there are approximately three urosteges, without regard to sex or age. This correlation is not perfect, however, for long-tailed snakes sometimes have a small number of urosteges and short-tailed snakes a large number; thus, one female with a tail just 21 per cent of the body has 65 urosteges, while another with the tail 22.5 per cent has only 63. Moreover, snakes with tails of the same length sometimes differ greatly in the number of urosteges; thus in the case of two males

having tails 25.5 per cent of the body length, one has 78 urosteges and the other only 70. The accompanying diagram (I) is designed to show the variability in length of tail and in number of urosteges, and also the correlation between those two characters.

5. *Greater Variability of Females.* — One of the most interesting facts brought out during this investigation is that female water snakes are far more likely to vary from the normal than are males. This is not a matter of size, for many of the aberrations are among the small snakes, and they do not seem to be more frequent among large specimens. Thus, of 11 females over 900 mm. in length, 45 per cent were normal as regards the labial plates and number of scale rows (the points in which the variability is most marked), while of 12 snakes less than 800 mm., less than 42 per cent were normal. In both *erythrogaster* and *sipedon* there are, normally, 8 labial plates on each side of the upper jaw and 10 on each side of the lower; the normal formula therefore is $\frac{8-8}{10-10}$. Now, of the 19 male *erythrogasters* examined, 16 possessed the normal number and arrangement of the labials, and of 33 male *sipedons*, 25 were normal; of 52 males, therefore, 41, or 79 per cent, were normal as regards the labials. Of the 8 female *erythrogasters*, only 4, and of 30 female *sipedons*, only 14, were normal; of 38 females, therefore, only 18, or 47 per cent, were normal as regards the labials. The 20 abnormal females show 26 variations from the normal, and of these 21, or 80 per cent, are *added* plates, while the 11 abnormal males show 16 variations, of which only 9, or 56 per cent, are added plates. Granting that these cases are too few to determine any general law of variability, they are nevertheless suggestive. Turning now to the number of scale rows on the back, we find additional evidence of the greater variability of females. The number of such rows is, normally, 23, counting where they are most numerous, which is usually about one-third of the total length, back of the head. Of the 52 males examined, 45 had 23 rows, 3 had 24, and 4 had 25; thus 86.5 per cent were normal. Of the 38 females, 29 had 23 rows, 6 had 24, and 3 had 25; thus, 76 per cent were normal. It ought perhaps to be emphasized that this increase

in number of scale rows is not correlated with size, for although the nine aberrant females average larger than most female *sipedons*, three of them average only 650 mm. and the seven aberrant males average 17 mm. less than the average male *sipedon*. From these figures it can be easily shown that about 68 males in 100 will have the normal number of scale rows and labials, but of 100 females only 36 can be expected to be normal in both respects. On looking over my list of 52 males

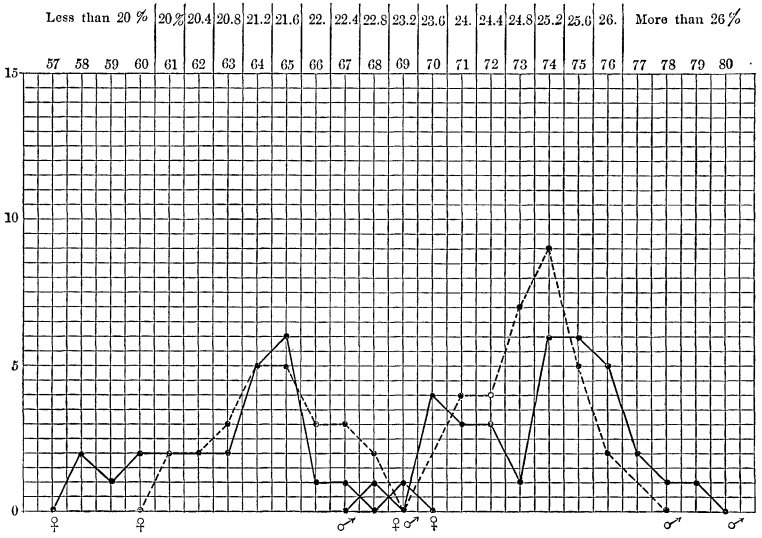

DIAGRAM I. — To illustrate the differences in the length of tail and in the number of urosteges in the two sexes of *N. f. sipedon*, and the correlation between those two characters.

———— = number of urosteges. ····· = the length of tail in percentage of total length. Horizontal lines represent the number of individuals. Vertical lines show the length of tail (upper row of figures) and also the number of urosteges (lower row of figures). Compiled from the statistics of 33 males and 25 females.

and 38 females, I find that this is about the proportion which prevails; there is, however, one less normal male and two more normal females than would be expected.

6. *Greater Variability of Lower Jaw.* — In comparing the variability of the sexes, the interesting fact was brought to light that the number of labials in the lower jaw is much more variable than the number in the upper jaw; that is to say, it is much more common to find 8—8 upper labials than 10—10 lower. Thus, of the 52 males, 50, or 96 per cent, have the

upper labials normal, while only 41, or 79 per cent, have normal lower labials; of the 38 females, 31, or 81.5 per cent, have normal upper labials, while only 22, or 58 per cent, have the lower normal. Thus, of 90 snakes, 81, just 90 per cent, have the normal number of upper labials, while only 63, or 70 per cent, have the lower labials normal. There is no well-marked difference between the right and left sides of the head, though it may be noted in passing that of 10 aberrations in superior labials, 7 were on the right-hand side, while of 32 aberrations in inferior labials, only 14 were on the right-hand side. It may further be noted that of the 10 aberrations in superior labials, all were due to *added* plates, while of the 32 aberrations in inferior labials, only 20 were due to added plates.

COMPARISON OF SIPEDON AND ERYTHROGASTER.

Having thus made clear some of the peculiarities which distinguish males from females and adults from young, in the water snakes under consideration, we may now pass on to a careful comparative study of the two so-called "subspecies." We do not need to stop and consider points of internal anatomy or those external characters which are common to both forms and serve to indicate their position in the genus Natrix. We will therefore take up those points wherein *erythrogaster* differs from *sipedon*, and see how marked and how constant those differences are.

1. *Size.* — There can be no question that *erythrogaster* is a larger snake than *sipedon*. As yet I have not seen a really small specimen of *erythrogaster*, while the smallest specimen of *sipedon* captured must have been born only a few days previously. The table at the top of the opposite page will make the difference in size clear.

The average *erythrogaster* is therefore considerably more than 25 per cent larger than the average *sipedon*. The contrast between the sexes is much more marked in *sipedon*, though even in *erythrogaster* the females are very decidedly larger. The absence of small specimens of *erythrogaster* is one of the most puzzling facts met with, and one for which it is difficult

TABLE IV.

Species.	Sex.	Number of Specimens.	Maximum Length in mm.	Minimum Length in mm.	Average Length in mm.
Erythrogaster	♂	16	1218	760	977
Erythrogaster	♀	8	1270	854	1060
Sipedon	♂	33	850	257	657
Sipedon	♀	25	1189	392	808

to account. Possibly the young are born later than those of *sipedon*, and careful searching in the late summer or early fall may yet reveal some of them.

2. *Proportions.* — When we come to compare the proportions of *sipedon* and *erythrogaster*, we have to bear in mind the fact that small snakes differ appreciably from large ones in the relative lengths of head and tail, and diameter of the eye. Thus, if we averaged all of the available *sipedons* and placed the averages beside those of the available *erythrogasters*, we should be led to some erroneous conclusions. For example, it would then seem that *sipedon* has a distinctly longer head than *erythrogaster*. That this is not so may be made easily apparent by taking the eight largest females and sixteen largest males of *sipedon* and comparing with the eight females and sixteen whole males of *erythrogaster*. This is as fair a choice as possible, since *erythrogaster* averages so much the larger, and the proportions of males and females are so different. The following table shows clearly the result of such comparison.

TABLE V.

Species.	Sex.	Number of Specimens.	Average Length in mm.	Length of Tail in Percentage of Total Length.	Length of Head* in Percentage of Body Length.	Diameter of Eye in Percentage of Head Length.
Erythrogaster	♂	16	977	23.7%	3.1%	21.1%
Erythrogaster	♀	8	1060	20.9%	3.1%	19.9%
Sipedon, largest	♂	16	726	24.5%	3.3%	19.1%
Sipedon	♀	8	989	20.8%	3.1%	17.5%

* In this, and in all cases where reference is made to head length, the measurement is from the most anterior point of the rostrum to the posterior edge of the occipital plates.

It will be seen that the females of the two forms agree remarkably in length of head and tail, while the male *sipedons* show only a very slight and unimportant increase over the males of the other form, and this slight increase is doubtless due to their very considerably smaller size. The one important point brought out by this table is that *erythrogaster* has a much larger eye than *sipedon*, the average difference being over 2 per cent. This is very noticeable in living and freshly killed

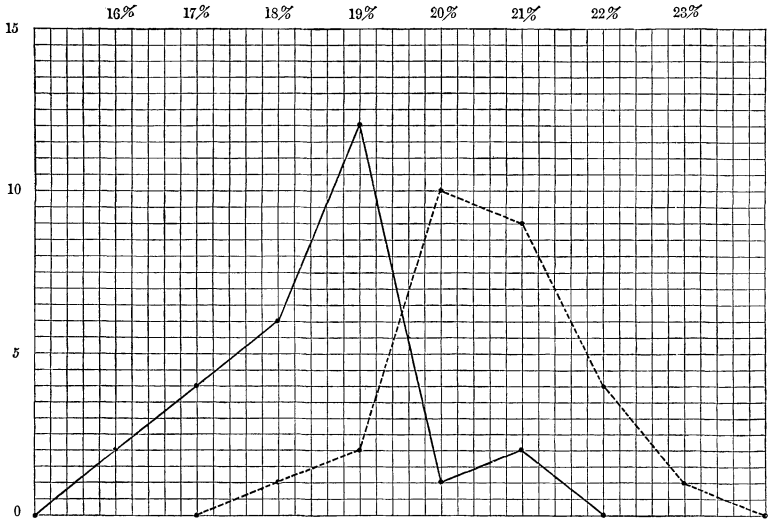

DIAGRAM II. — To illustrate the difference in the size of the eye, between *N. f. sipedon* and *N. erythrogaster*.

———— = *sipedon*. ..... = *erythrogaster*. Horizontal lines represent the number of individuals. Vertical lines represent the diameter of the eye in percentage of head length. Compiled from the measurements of 27 *erythrogasters* and 27 large *sipedons*.

snakes, but it is obvious in preserved specimens. Of the 27 specimens of *erythrogaster*, none had the eye less than 4.5 mm. in diameter, while 20 had it 5 mm. or more, and in four of these it was 6 mm. Of 63 specimens of *sipedon*, on the other hand, only six had the eye more than 4 mm. in diameter, and in only two of these did it measure 5 mm. The accompanying diagram (II) shows at a glance the relative size of the eye in the 27 *erythrogasters* and the corresponding 27 *sipedons* (8 largest females and 19 largest males). In this diagram, percentages

between 15.6 and 16.5, inclusive, are reckoned as 16 per cent, those between 16.6 and 17.5 as 17 per cent, and so on.

It is worth noting that the three *sipedons* with eyes over 19 per cent of the head length and the three *erythrogasters* with eyes over 21 per cent are all large males, while the *erythrogasters* with eyes less than 20 per cent are large females. A glance at Table V will show that there is other evidence to indicate that males have slightly larger eyes than females. The difference, however, is hardly sufficient to be easily recognized.

3. *Number of Urosteges.* — Reference to Table III will show that the male *erythrogaster* averages three, and the female four, more urosteges than the corresponding sex of *sipedon*. This is rather noteworthy in view of the fact that there is no appreciable difference in the length of the tail in the two forms. The same point may be illustrated by selecting a few examples of *sipedon*, giving the total length and the number of urosteges, and placing above each the corresponding specimen of *erythrogaster* of the same sex, which is, of all on the list, nearest in size. Thus:

Erythrogaster,	♀,	1182 mm.	long	has 68	urosteges.
Sipedon,	♀,	1189 "	"	" 61	"
Erythrogaster,	♀,	1030 "	"	" 70	"
Sipedon,	♀,	1030 "	"	" 65	"
Erythrogaster,	♂,	806 "	"	" 77	"
Sipedon,	♂,	794 "	"	" 74	"
Erythrogaster,	♂,	760 "	"	" 79	"
Sipedon,	♂,	774 "	"	" 77	"

Although these cases were selected at random, they are purely illustrative, and not at all decisive. Examples might be given showing opposite conditions. Nevertheless, it must be admitted that *erythrogaster* seems to have, normally, a few more urosteges than *sipedon*.

4. *Number of Gastrosteges.* — In no respect, except color, is there shown such a marked difference between *erythrogaster* and *sipedon* as in the number of gastrosteges, a character which is of great importance in distinguishing different species of snakes. It is important to note here that there is no evident connection between the number of gastrosteges and sex or

size. That it is not a matter of sex is shown by the fact that the females of *erythrogaster* average 151.4 gastrosteges apiece and the males 150.8, while in *sipedon* the females average 141.7 and the males 142.9. These differences seem too small to have any significance. That the number of gastrosteges is not dependent on size is shown by the fact that the five largest *sipedons*, averaging 1066 mm. in length, have only 143.8 gastrosteges each, while the five smallest, averaging only 440 mm.,

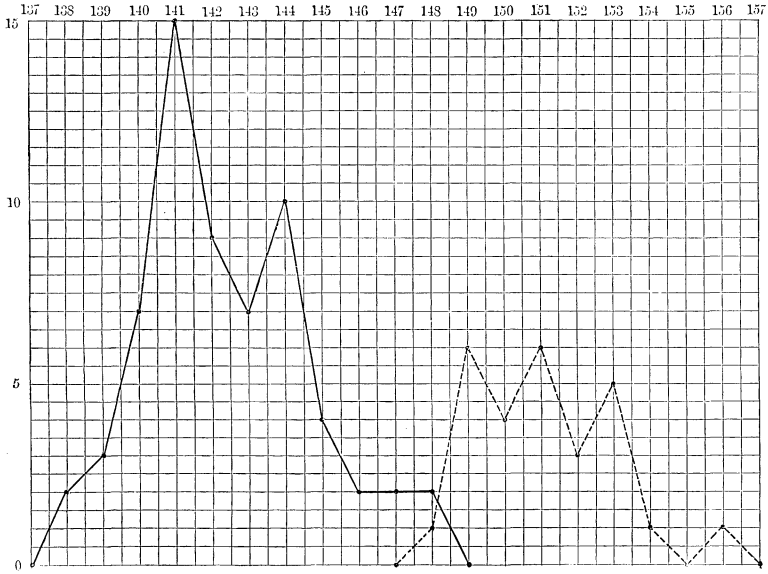

DIAGRAM III. — To illustrate the difference in the number of gastrosteges between *N. f. sipedon* and *N. erythrogaster*. The anal plate is not included.

————— = *sipedon*. ····· = *erythrogaster*. Horizontal lines represent the number of individuals. Vertical lines represent the number of gastrosteges. Compiled from the statistics of 27 *erythrogasters* and 63 *sipedons*.

have 144.2 gastrosteges each. Comparing *erythrogaster* and *sipedon*, without reference to age or sex, we find that the former has on the average 151 gastrosteges, while the latter has only 142. But the difference between the two forms is made most apparent by the accompanying diagram (III).

It will be seen at once that 148 is the maximum number for *sipedon*, and, at the same time, is the minimum number for *erythrogaster*. It ought to be stated that occasionally an imperfect

or half plate occurs at the side between two gastrosteges. This was the case in one female *erythrogaster* and in two males and two females of *sipedon*. In all such cases the extra plate has been counted as an additional gastrostege.

5. *Color.* — In dealing with the matter of color, we meet with great difficulties, owing to the impossibility of stating differences with mathematical exactness. Moreover, in no other particular is there so much room for difference of personal opinion and so many chances for errors of judgment. Nevertheless, since it is in the matter of color that *sipedon* and *erythrogaster* exhibit their most constant and striking difference, it is absolutely essential to any proper understanding of the relation of the two forms that this difference be clearly shown. First of all, therefore, an exact description of the typical coloration of each form in life will be given, using the color names of Ridgway's *Nomenclature of Colors*.

Erythrogaster. Dorsal surface black, passing through slate black and blackish slate to nearly slate color on sides; ventral surface bright rufous, orange rufous, or even Chinese orange, shading anteriorly through saturn red to deep chrome on the throat and finally to creamy white on the chin; whole head with a reddish tinge; upper labials nearly rufous except on upper and anterior edges; outer, anterior edges of gastrosteges more or less slate color, the same shade being more or less evident on urosteges.

Sipedon. Dorsal surface dark bister with irregular, narrow, transverse bands of wood brown; beginning on the fifth or sixth row of scales, and running down vertically on sides, are broad, pale, almost whitish bands, anteriorly and posteriorly continuous with, but for the most part alternating with, the transverse bands on back; between these vertical lateral bands the scales are chocolate brown, more or less mottled with black; chin creamy white; gastrosteges creamy white, anteriorly with two semicircular spots of hazel or ferruginous, the arc of the semicircle coincident with the anterior edge of gastrostege; farther back additional ferruginous spots appear, and these gradually merge together, at the same time becoming more and more clouded with black, so that near the vent the

gastrosteges are black with a little white on the posterior edges; urosteges mostly black, with inner edges white; head mottled, light and dark brown; lower edge of upper labials pale gray.

The colors of *sipedon* do not undergo a very marked change during a few months in alcohol or formalin, simply becoming more dull, though after the lapse of years they fade, especially if exposed to the light. The colors of *erythrogaster*, however, are completely changed in either formalin or alcohol, the black tending to become bister or clove brown and the whole under surface becoming pale cream color, with faint indications of slate on the anterior edges of the gastrosteges. The twenty-seven specimens of *erythrogaster* collected about Olivet showed practically no variation in color, except that a few had the mid-ventral line a somewhat deeper shade of rufous. In no case was there the slightest evidence of markings on the back, or of spots on the belly. The sixty-three specimens of *sipedon*, on the other hand, show a very wide range of variation, not only in the distinctness of the markings and in the amount of brown and black on the ventral surface, but also in the shade of the ground color, both dorsally and ventrally. The middle of the ventral surface is often marked with an ill-defined longitudinal area of yellowish, sometimes almost reddish yellow. Just before the shedding of the skin, the black of *erythrogaster* becomes very dull, and the ventral side a dull, almost salmon, red, quite different from the normal shade. In captivity this stage may last two or three weeks, but in freedom it is probably passed through more rapidly. In *sipedon* the casting of the skin causes a preliminary obscuring of the dorsal markings, so that in cases where they are naturally faint they may be apparently wanting.

However much specimens of *sipedon* varied from normal, none of those examined showed the slightest approach to *erythrogaster*, and it is very difficult to see how the coloration of the latter could ever have gradually developed from that of the former. While still seeking a solution of this puzzle, four specimens of Natrix from the United States National Museum were very kindly loaned to me by Dr. Stejneger. Of these I shall have more to say later. Suffice it to say here that they

helped me to imagine the steps by which *erythrogaster* might have developed from *sipedon*, although it by no means follows that such were the steps. The following ten are the stages that I have selected, but they are of course arbitrary, and I could easily have subdivided the sixty-three *sipedons* into a dozen color varieties, would such a division have been of any service.

TABLE VI.

Reference No.	Dorsal Ground Color.	Dorsal Markings.	Ventral Ground Color.	Ventral Markings.
1	Brown	Indistinct	Creamy or yellowish	Some brown and much black
2	Brown	Distinct	Creamy or yellowish	Some brown and much black
3	Brown	Distinct	Yellowish	Brown and black
4	Brown	Distinct	Yellowish, with red tinge	Brown and black
5	Blackish	Distinct	Yellowish rufous	Little brown; much blackish slate
6	Black	Indistinct	Yellowish rufous	No brown; much slate
7	Black	Indistinct	Rufous	Much slate on anterior half of gastrosteges
8	Black	None	Rufous	Much slate on anterior half of gastrosteges
9	Black	None	Bright rufous	Little slate on anterior edges of gastrosteges
10	Black	None	Bright rufous	Deep rufous on mid-ventral surface; very little slate

Although these are such hypothetical stages, more than half of them occur among the ninety snakes I have examined. The following diagram will show at a glance their relative abundance, but it will of course be borne in mind that the first four stages, which include all of the *sipedons*, might have been divided up into a much larger number of color varieties had it been desirable. This would not, however, have affected in any way whatever the great gap between stages 4 and 8. The only purpose of this diagram is to show plainly that gap.

Although, of course, this diagram is not really comparable with that showing the number of gastrosteges, since we are dealing here with a purely artificial arrangement and not with

exact numerical series, yet it is interesting to see how the separation of *erythrogaster* from *sipedon*, so evidently shown by the diagram of gastrosteges, is emphasized by this diagram of color.

6. *Variability.*— It has already been shown that female water snakes are more variable than males in the number of scale rows and labials. It is interesting to see that in both these

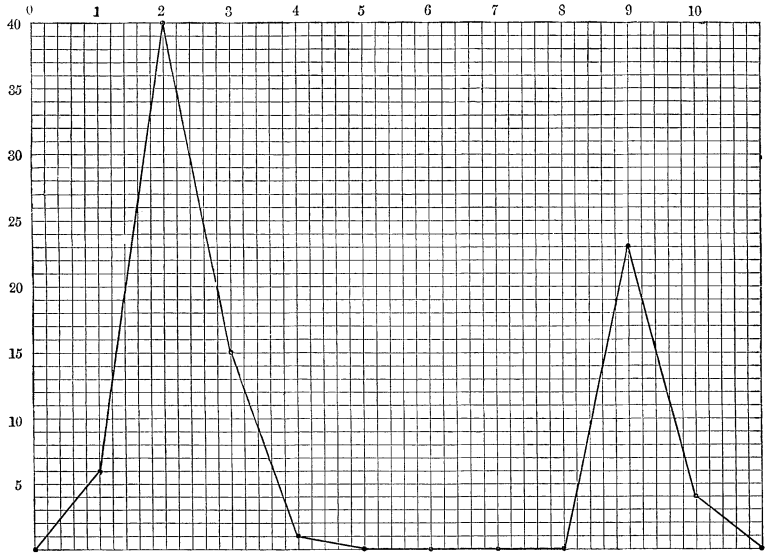

DIAGRAM IV.—To illustrate the difference in color between *N. f. sipedon* and *N. erythrogaster*. The numbers at the left indicate the number of individuals. The numbers at the top indicate the type of coloration as given in Table VI. Compiled from the records of 27 *erythrogasters* and 63 *sipedons*.

respects, as well as in color, *sipedon* is far more variable than *erythrogaster*. This is clearly shown by the table on the opposite page.

It may further be stated that there are two specimens of *erythrogaster*, one male and one female, which are apparently normal in every respect, as they have the average number of gastrosteges (151) and of urosteges (77 and 67 respectively), the proper number of labials on each jaw $\left(\frac{8-8}{10-10}\right)$, and the proper number of scale rows (23). Such a normal individual of *sipedon* is not to be found among my 63 specimens. In Table II may be found another illustration of this same point, for it

there appears that the range of variability in the length of tail is over 10 per cent in *sipedon* and only a little over 5 per cent in *erythrogaster*. We have already seen that *sipedon* is much more common and much less restricted in its range than *erythrogaster*, and since it is clearly much more variable, these facts serve as an excellent illustration of the generally accepted belief that common and wide-ranging species are the most variable.

TABLE VII.

Species.	Sex.	Number of Specimens.	Number with Upper Labials, 8-8.	Percentage Normal.	Percentage for Species.	Number with Lower Labials, 10-10.	Percentage Normal.	Percentage for Species.	Number with 23 Rows of Scales.	Percentage Normal.	Percentage for Species.	Number Normal in all Three Particulars.	Percentage Normal.	Percentage for Species.
Erythrogaster	♂	19	18	95%	92%	16	84%	74%	18	95%	96%	15	79%	70%
Erythrogaster	♀	8	7	87.5%		4	50%		8	100%		4	50%	
Sipedon	♂	33	32	97%	89%	25	76%	68%	27	81%	76%	19	57.5%	49%
Sipedon	♀	30	24	80%		18	60%		21	70%		12	40%	

THE SYSTEMATIC POSITION OF ERYTHROGASTER.

With these facts before us, we may well consider what light they throw on the real relationship of the red-bellied black snake to the common water snake. The table on the following page will help to set before us, so that they may be readily grasped, the points of resemblance and difference between the two.

In the relative length of head and tail, in the number of scale rows, and in the number and arrangement of labials, there is evident agreement between the two forms; but, on the other hand, *erythrogaster* is a larger snake than *sipedon*, the male especially averaging 50 per cent more (see Table II), the eye is very much larger, the gastrosteges are more numerous, the urosteges slightly more numerous, the color is totally different, the odor is distinguishably different, and the percentage of variability is very much less. In addition to these characters, certain peculiarities of habits and habitat help to distinguish

TABLE VIII.

Species.	Average Length in mm.	Average Length of Tail in Percentage of Total Length.	Average Length of Head in Percentage of Body Length.	Average Diameter of Eye in Percentage of Head Length.	Number of Scale Rows.	Number and Arrangement of Labials.	Average Number of Gastrosteges.	Average Number of Urosteges.	Color.	Color and Odor of Secretion of Postanal Glands.	Percentage of Variability in		
											Labials.	Scale Rows.	Both.
Erythrogaster	1019	22.3%	3.1%	20.5%	23	8-8 / 10-10	151	72	Black above, rufous beneath; no markings	White to light yellow; musky, slightly acid	26%	4%	30%
Sipedon	733	*22.7%	*3.2%	*18.3%	23	8-8 / 10-10	142	68.5	Brown above, cream color beneath; cross bands above, blotches beneath	Yellow or brownish; somewhat "burnt" and disagreeable	38%	24%	51%

* Average of 8 largest females + 16 largest males, for reasons already given.

erythrogaster from its more common relative. Were all our knowledge of these two snakes confined to what has been learned about them from the study of these Olivet specimens, the proper course would be simple and no one would hesitate to write *Natrix erythrogaster* as a good species. But unfortunately for the followers of such an easy course, *Natrix fasciata* is a very widely distributed and variable species, and water snakes referred to the subspecies *erythrogaster* have been taken in many parts of the United States south of Michigan, and even in Mexico. In fact, *erythrogaster* is regarded as characteristic of the Austroriparian district, and its occurrence in Michigan is looked upon as an extreme northward extension of its range.

Through the kindness of Dr. Stejneger, to which reference has already been made, there were sent me from the National Museum three specimens of Natrix, which were referred to *erythrogaster* by Cope, and a fourth specimen, from the Dismal Swamp, Virginia. All are females. Let us now examine these specimens carefully:

1. The specimen from the Dismal Swamp (National Museum, No. 26,256) resembles the Olivet *erythrogasters* very closely,

but is smaller than any of my specimens (712 mm.) and has a much longer head and tail proportionately. These differences may be due, however, to the measurements having been made from the preserved specimen, in which the body would naturally have shrunk more than the head or tail. So far as can be judged from preserved material, the color was originally the same as in Olivet specimens. This snake clearly throws no light on the question of relationship to *sipedon*, but it leaves little doubt in my mind that the Virginia and Michigan snakes are identical.

2. The second specimen (National Museum, No. 1350) is a small snake less than 600 mm. long, collected many years ago by Professor Agassiz at "Lake Huron." It has only 146 gastrosteges, the diameter of the eye is less than 19 per cent of the head length, and the markings on the upper surface are those of *sipedon*. The tail is broken so that the number of urosteges could not be determined exactly, and the whole specimen is so badly faded that it is not possible to say what the colors or markings of the ventral surface were in life, but there are no distinct dark markings on the gastrosteges. In spite of this, however, the snake seems to me clearly a *sipedon* and it probably never even approached *erythrogaster*.

3. The third specimen (National Museum, No. 1351) is from St. Louis, Mo., and is also an old and faded specimen, but the presence of light transverse bands, bordered with black, across the back is very evident. Underneath the specimen is practically unmarked, and it may have been rufous, like *erythrogaster*. The diameter of the eye is 23 per cent of the head length, and there are 152 gastrosteges, but there are 24 rows of scales and only 61 urosteges. The specimen is probably an *erythrogaster*, with evident indications of relationship to some *sipedon*-like form.

4. The fourth specimen (National Museum, No. 1341) is from Lansing, Mich., less than thirty miles from Olivet, and is also old and badly faded. It has the diameter of the eye 20 per cent of the head length, 151 gastrosteges, 64 urosteges, and 25 rows of scales. It is like *erythrogaster* in color, except that at intervals of 20 mm. along the middle of the back are indications of dark transverse markings.

In the Olivet College museum there is a specimen of *erythrogaster*, a female, taken at Olivet in the spring of 1889, which is the largest water snake I have yet seen. The tail is broken, but careful calculation for the lost portion shows that the specimen was certainly over 1300 mm. in length. The eye is 6.5 mm. in diameter, 22 per cent of the head length; there are 154 gastrosteges and 25 rows of scales. There are no dorsal markings of any kind, but the ventral surface is mottled with a great deal of slate color along the sides, especially near the vent, on the posterior gastrosteges and the urosteges. The coloration is therefore No. 8 of Table VI.

We have here, then, three (or possibly four) snakes which seem to be what might be considered connecting links between *erythrogaster* and *sipedon*, or some other form of *fasciata*. Are they really such? Two facts must be noted: first, all are old specimens, the most recent having been taken thirteen years ago, and that one is most nearly a typical *erythrogaster;* second, all are females, the variable sex, and are aberrant in number of scale rows, urosteges, or gastrosteges. They are not, therefore, actually intermediate forms, but individuals which have varied from the normal in color as well as in some other particular. The smallest of my specimens of *erythrogaster*, a male 760 mm. long, was kept in captivity for six weeks, at the end of which time he shed his skin. Although when captured his coloration was perfectly normal, without a trace of markings, his new suit showed along the sides faint indications of lighter, vertical bands, visible only in just the right light. Might this not indicate the ancestry, as the spots on the breast of a young robin indicate its ancestry, without making the individual in any sense a connecting link?

All of the evidence so far collected seems to me to show that we have in *Natrix erythrogaster* a well-defined species of water snake, probably derived from some form of *fasciata*, though probably not *sipedon*. Possibly the separation has been completed during the nineteenth century and the specimens in the National Museum, referred to above, are some of the last connecting links, though I am inclined to regard them merely as unusually aberrant females. At any rate, what we need

now is fresh evidence and much of it. Are connecting links between *erythrogaster* and any forms of *fasciata* now to be found anywhere? Do *erythrogaster* and forms of *fasciata* breed together? Do the females of *erythrogaster* ever produce any young that are not clearly young *erythrogasters?* Do the females of any form of *fasciata* ever produce *erythrogasters?* Until some or all of these questions are answered in the affirmative, *erythrogaster* is entitled to rank as a distinct species of Natrix. But there is still much to learn as to its range and its breeding habits.

OLIVET COLLEGE, MICHIGAN,
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